

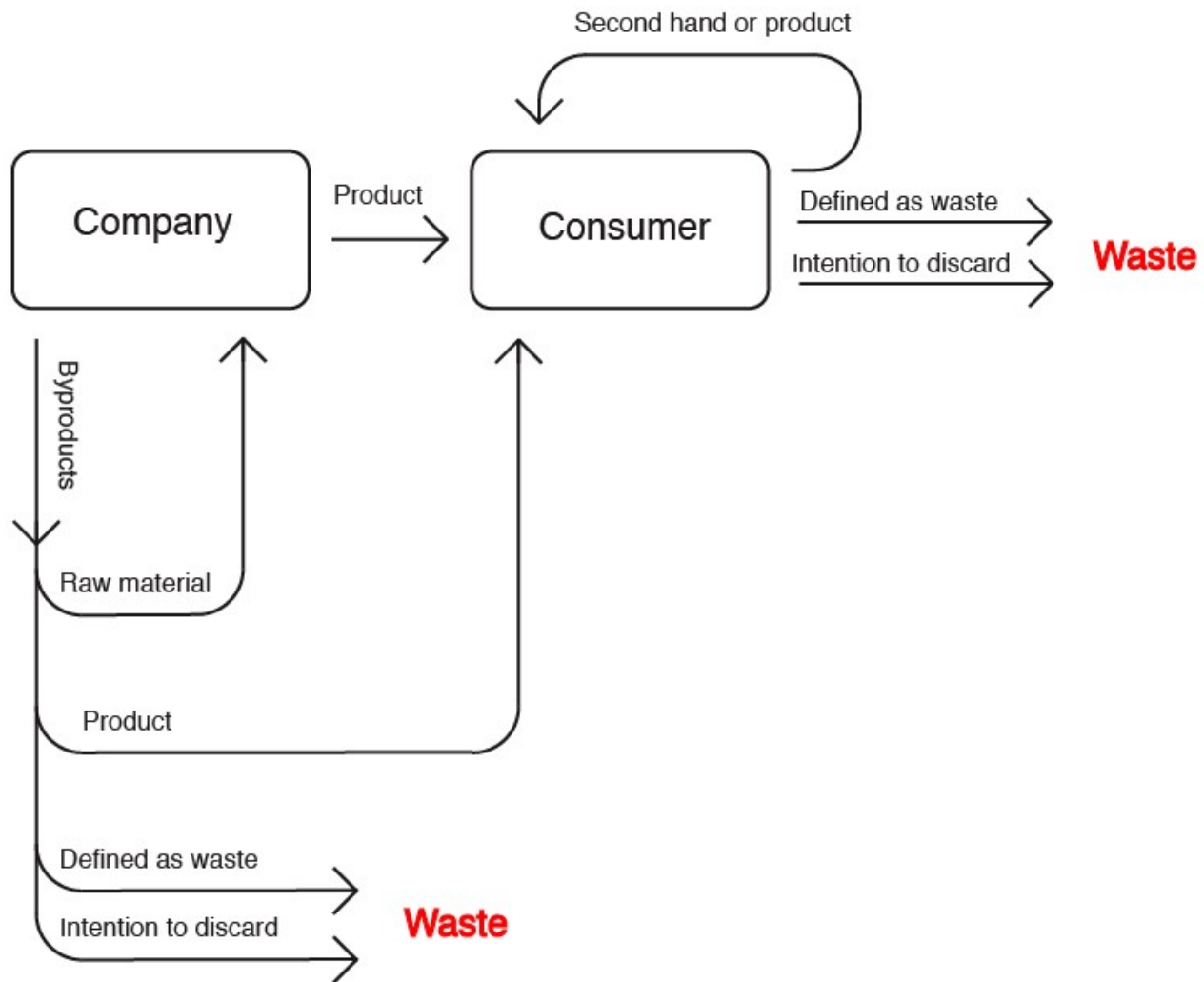
SAS4311 Green Chemistry

Waste Production,
Minimization and Treatment

- Waste is a natural consequence of all human activity including the actual process of living.
- On average each adult produces over 300 g of faeces and 1 litre of urine per day.

Classification and Source of Waste

- **Defintion:** *any substance or object which the producer or the person in possession of it, discards or intends or is required to discard.*



Classification of waste

- 1. Municipal Solid Waste (MSW)
 - comprises solid waste from households, commercial and industrial sources. This excludes construction and demolition waste, chemical waste and other special waste. MSW is disposed of at landfills.

- 2. Construction waste includes waste arising from such activities as construction, renovation, demolition, land excavation and road works. Ideally, the waste is separated and inert material is used as fill in reclamation sites, when available. However, a significant portion of the waste still goes to landfills.
- 3. Chemical waste comprises substances produced from chemical industry and laboratory. For example. Organic solvents (Tetrachloroethylene in dry cleaning, toluene in paint thinner, acetone in nail polish removers, hexane in spot remover, etc) Innocuous aqueous waste (aqueous solution of sodium chloride), spent acid and bases, etc.

- 4. Special wastes include
 - Clinical waste - waste from medical premises or laboratory that has the potential to cause disease, including, for example, medical and microbiological laboratory waste, animal and human tissue, blood, swabs and dressing.
 - Animal carcasses -animal dead bodies (intact, or parts); offal; condemned meat .

- Radioactive waste - comprises smoke detector parts, nuclear medicine for medical diagnosis.
- Grease trap waste - Oil and grease in wastewater arising from normal operations of restaurants and food processing factories will need to be separated out, commonly by means of grease traps, before the wastewater is discharged from the premises. The oil and grease intercepted by grease traps, usually known as grease trap waste.

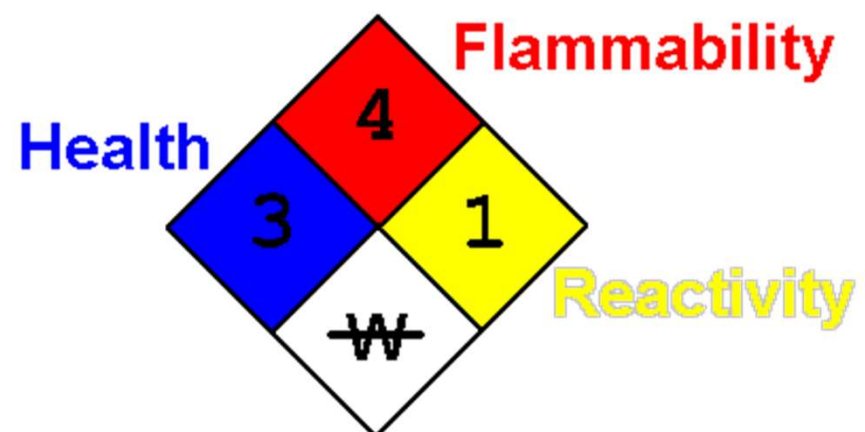
Characteristic of Hazardous Wastes

- 1. Ignitability - Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60°C (140°F). Examples include waste oils and used solvents.
- 2. Corrosivity - Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums, and barrels.

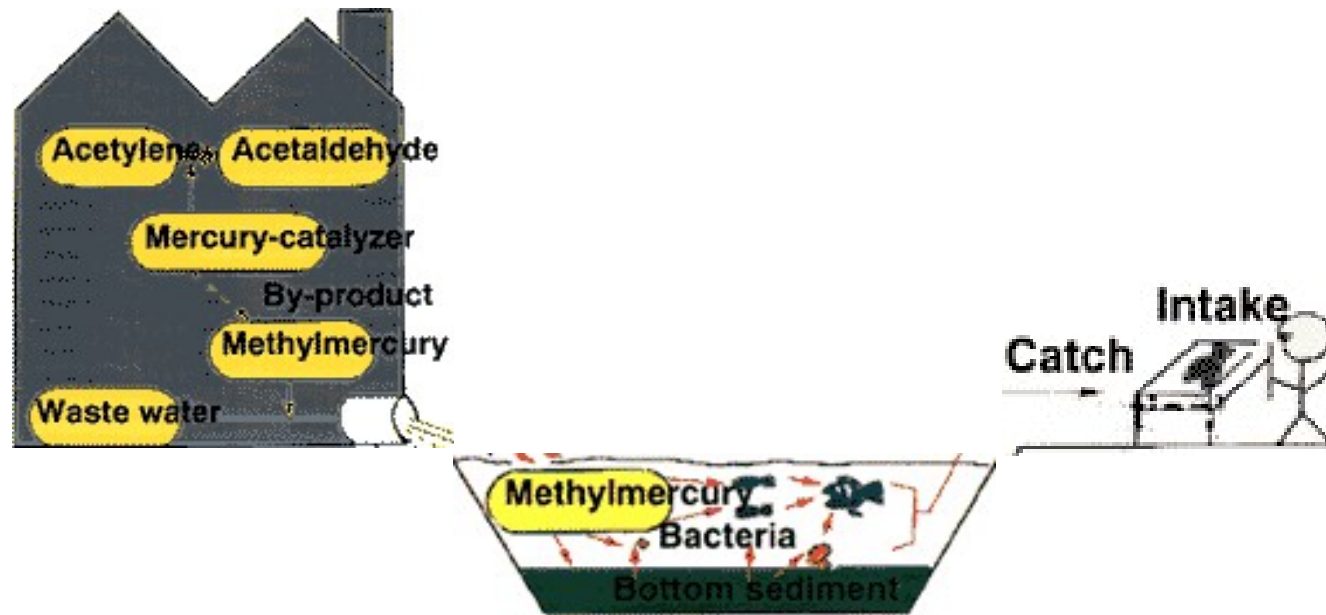
- 3. Reactivity - Reactive wastes are unstable under "normal" conditions. They can cause explosions, toxic fumes, gases, or vapors when heated, compressed, or mixed with water. Examples include lithium-sulfur batteries and explosives.
- 4. Toxicity - Toxic wastes are harmful or fatal when ingested or absorbed (e.g., containing mercury, lead, etc.). When toxic wastes are land disposed, contaminated liquid may leach from the waste and pollute ground water.

Classification System

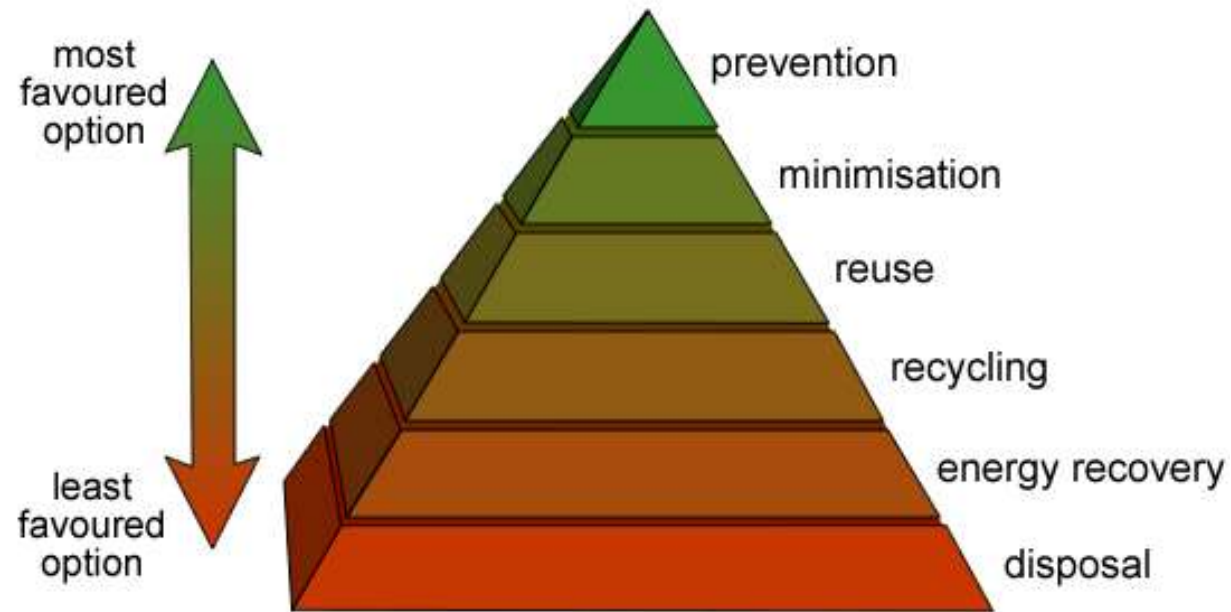
- NFPA - A standard maintained by the U.S.-based National Fire Protection Association.
- The four divisions are typically color-coded, with blue indicating level of health hazard red indicating flammability yellow (chemical) reactivity, and white containing special codes for unique hazards. Each of health, flammability and reactivity is rated on a scale from 0 (no hazard; normal substance) to 4 (severe risk).



Mercury Poisoning at Minamata Bay in Japan



Waste Management and Treatment



Waste Minimization

Source Separation of Domestic Waste

家居廢物源頭分類計劃
Programme on Source Separation of Domestic Waste

廢物回收助環保・樓層分類成效高
Separate Waste at Source・Improve our Environment

✓ 在樓層分類 Source Separation on Each Floor
✓ 擴大回收物料種類 More types of Recyclable Material

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www.epd.gov.hk

可回收物料 Recyclable Materials				不可回收物料 Non-Recyclable Materials	
廢紙 Waste Paper	✓	報紙、雜誌、宣傳單張、信封等 newspapers, magazines, leaflets, envelopes, etc.	物件包裝紙盒、蛋盒 packaging materials & egg cartons	購物紙袋 paper shopping bags	✗ 含有塑膠 / 鋁金屬層的紙包裝飲品或牛奶盒 beverage or milk cartons with plastic or aluminium interior coatings
金屬 Metals	✓	鐵 / 鋁罐 (清潔) steel / aluminium cans (clean)	奶粉罐 milk powder cans	煮食器具 cookware	✗ 月餅盒 (塑膠托盤應分至塑膠類) mooncake cans (plastic trays should be recovered as plastics)
塑膠 Plastics	✓	膠樽和樽蓋 (清潔) plastic bottles & caps (clean)	塑膠容器 (例如: 膠桶、清潔食物膠盒) 及膠椅 plastic containers (e.g. buckets, clean food containers) & chairs	購物膠袋、塑膠包裝 (清潔乾淨) shopping bags, plastic wrappings (clean & dry)	✗ 光碟、錄音 / 影帶及雷射影碟 CD, DVD, cassette / video tapes & laser discs
其他可回收物料 Other Recyclable Materials	✓	舊衣及玩具 (清潔乾淨) old clothing & toys (clean & dry)	碳粉盒 ink cartridges	電腦、電器及電子用品 computers, electrical & electronic appliances	✗ 玩具及文具 toys & stationery
充電電池 Rechargeable Batteries	✓	所有充電電池, 包括一般獨立充電電池及電腦附設充電電池 All rechargeable batteries, including general purpose and small electronic devices. Please ask your estate management office for the location of collection box at your estate.			
主要收集點: 豐華・SUNDAY・豐盛苑・地鐵站・九龍車站・觀塘道站・豐華商場・豐華商場・豐華商場 (1/2層) Major Collection Points: Fairness, SUNDAY, Wellcome, MTR Stations, KCR Stations, Shell Stations, Wellcome & T-ELVEN* (*Selected)				其他未能回收物料 Other non-recyclable materials 廚餘 (棄置前請盡量去除水分) food waste (residue water should be drained before disposal) 玻璃、電燈泡、陶瓷 glass, light bulbs, ceramics 含有鋁金屬層的塑膠包裝袋 plastic bags with aluminium interior coatings 受污染的物料 contaminated materials	

用再造紙印製 Printed on recycled paper

- **Recycling** - processing used materials into new products. It is a key component of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy.

Benefits:

- Protects and expands manufacturing jobs and increases competitiveness.
- Reduces the need for landfilling and incineration.
- Prevents pollution caused by the manufacturing of products from virgin materials.

Benefits:

- Saves energy.
- Decreases emissions of greenhouse gases that contribute to global climate change.
- Conserves natural resources such as timber, water, and minerals.
- Helps sustain the environment for future generations.

Ways of Recycling:

- Produce a fresh supply of the same material, for example used office paper to more office paper, or used foamed polystyrene to more polystyrene.
- often difficult or too expensive (compared with producing the same product from raw materials or other sources),

- **Reuse** in producing different materials (e.g., cardboard) instead.
- **Salvage** 廢物利用 of certain materials from complex products, either due to their intrinsic value (e.g., lead from car batteries), or due to their hazardous nature (e.g., removal and reuse of mercury from various items).


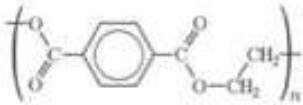

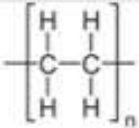

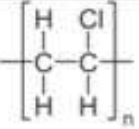

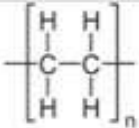

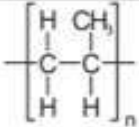

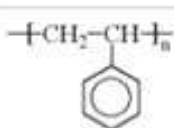

Types of Recycling

- **1. Concrete recycling** is an increasingly common method of disposing of the rubble.
- Concrete aggregate collected from demolition sites is put through a crushing machine, often along with asphalt, bricks, dirt, and rocks. Crushing facilities accept only uncontaminated concrete, which must be free of trash, wood, paper and other such materials.

- Smaller pieces of concrete are used as gravel for new construction projects.
- Sub-based gravel is laid down as the lowest layer in a road, with fresh concrete or asphalt poured over it. Crushed recycled concrete can also be used as the dry aggregate for brand new concrete if it is free of contaminants.
- Larger pieces of crushed concrete, i.e. rip-rap, can be used for erosion control.

- **2. Plastic Recycling** - the process of recovering scrap or waste plastics and reprocessing the material into useful products.
- Compared to glass or metallic materials, plastic poses unique challenges. Because of the massive number of types of plastic, they each carry a resin identification code, and must be sorted before they can be recycled.
- No easy sorting capability exists for plastics.

- Labels do not need to be removed from bottles for recycling, lids are often made from a different kind of non-recyclable plastic.
- plastic polymers recycling is often more challenging because of low density and low value.
- Plastic pyrolysis can convert petroleum-based waste streams such as plastics into fuels and carbons.

Resin Code	Polymer Resin	Structure	General Applications
 PET	Polyethylene Terephthalate		<ul style="list-style-type: none"> Plastic drinking bottles Food jars
 HDPE	High Density Polyethylene		<ul style="list-style-type: none"> Shampoo, dish, laundry and house cleaning bottles Shipping containers
 PVC	Polyvinyl Chloride		<ul style="list-style-type: none"> Packaging materials Pipes, fencing Blood bags, medical tubing
 LDPE	Low Density Polyethylene		<ul style="list-style-type: none"> Bags for dry cleaning & newspapers Shrink wrap, film
 PP	Polypropylene		<ul style="list-style-type: none"> Medicine bottles Bottle caps Automotive parts Carpeting
 PS	Polystyrene		<ul style="list-style-type: none"> Disposable cups, utensils, food containers Foam packaging
 OTHER	Other	Resin is other or a mixture of mentioned resins	<ul style="list-style-type: none"> 3 and 5 gallon reusable water bottles Packaging

3. Battery Recycling

- Battery recycling is a recycling activity that aims to reduce the number of batteries being disposed as municipal solid waste.
- <https://www.youtube.com/watch?v=oJj5ilwF8p4>

Lead Acid Battery Recycling

- The battery is broken apart in a hammer mill; a machine that hammers the battery into pieces. The broken battery pieces are then placed into a vat大桶, where the lead and heavy materials fall to the bottom and the plastic floats.

- ◉ **Lead**

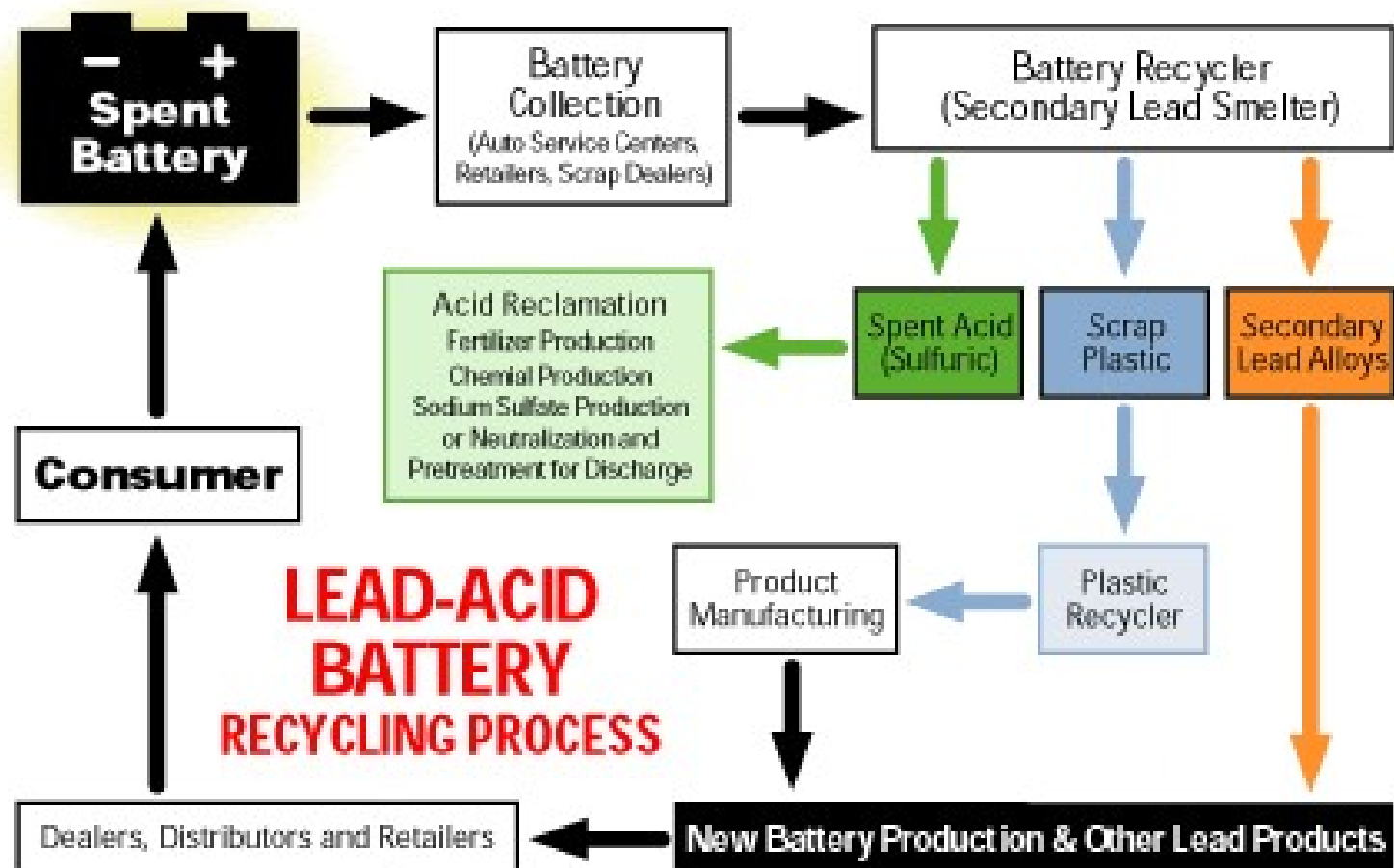
- ◉ Lead grids, lead oxide, and other lead parts are cleaned and heated within smelting furnaces.
- ◉ The molten melted lead is then poured into ingot molds. After a few minutes, the impurities float to the top of the still molten lead in the ingot molds.
- ◉ These impurities are scraped away and the ingots are left to cool.

- When the ingots are cool, they're removed from the molds and sent to battery manufacturers, where they're re-melted and used in the production of new batteries.

Sulfuric Acid

- Old battery acid can be handled in two ways: 1) The acid is neutralized with an industrial compound similar to household baking soda. Neutralization turns the acid into water. The water is then treated, cleaned, tested in a waste water treatment plant to be sure it meets clean water standards.

- 2) The acid is processed and converted to sodium sulfate, an odorless white powder that's used in laundry detergent, glass, and textile manufacturing.



Biodegradable Waste

- **Biodegradable waste** is a type of waste, typically originating from plant or animal sources, which may be broken down by other living organisms.
- Through proper waste management, it can be converted into valuable products by composting, or energy by waste-to-energy processes such as anaerobic digestion and incineration.

Composting

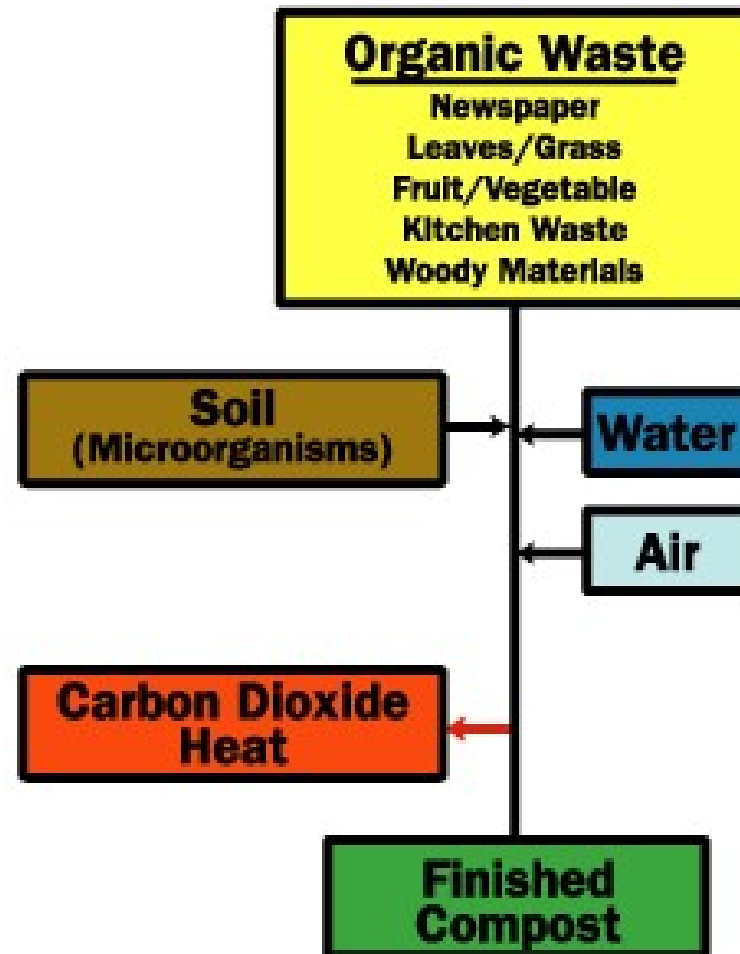
- A method for treating solid waste in which organic material is broken down by microorganisms in the presence of oxygen to a point where it can be safely stored, handled and applied to the environment.

Composting Ingredients

- **Organic waste** - newspaper, leaves, grass, kitchen waste (fruits, vegetables), woody materials
- **Soil** - source of microorganisms
- **Water**
- **Air** - source of oxygen

- This produces a fiber-rich, carbon-containing **humus** with inorganic nutrients like nitrogen, phosphorus and potassium. The microorganisms break the material down through **aerobic respiration**, and require oxygen that they get from the air you introduce when you turn the material in the compost bin.

- Through the respiration process, the microorganisms give off carbon dioxide and heat -- temperatures within compost piles can rise as high as 100 to 150 degrees Fahrenheit (38 to 66°C).
- If the compost pile or bin is actively managed by turning and watering it regularly, the process of decomposing into finished compost can happen in as little as two to three weeks



- The compost conditions must be balanced for efficient decomposition. There must be:
 - **Plenty of air** - mixture should be turned daily or every other day
 - **Adequate water** - mixture should be moist, but not soaking wet
 - **Proper mix of carbon to nitrogen** - ratio should be about 30:1
 - **Small particle size** - big pieces should be broken up, as smaller particles break down more rapidly
 - **Adequate amount of soil** - should provide enough microorganisms for the process

<u>Material</u>	<u>C:N Ratio</u>
<u>Coffee Grounds</u>	<u>20:1</u>
<u>Corn Stalks</u>	<u>60:1</u>
<u>Cow Manure</u>	<u>20:1</u>
<u>Fruit Wastes</u>	<u>35:1</u>
<u>Grass Clippings</u>	<u>20:1</u>
<u>Horse Manure w/ Litter</u>	<u>60:1</u>
<u>Leaves</u>	<u>60:1</u>
<u>Newspaper</u>	<u>50-200:1</u>
<u>Oak Leaves (Green)</u>	<u>26:1</u>
<u>Peat Moss</u>	<u>58:1</u>
<u>Pine Needles</u>	<u>60-110:1</u>
<u>Rotted Manure</u>	<u>20:1</u>
<u>Sawdust / Wood</u>	<u>600:1</u>
<u>Sawdust Weathered for two months</u>	<u>325:1</u>
<u>Straw</u>	<u>80-100:1</u>
<u>Table Scraps</u>	<u>15:1</u>
<u>Vegetable Trimmings</u>	<u>12-20:1</u>

<https://www.youtube.com/watch?v=wOQZuUHYlnk>

<https://www.youtube.com/watch?v=M1klpCBD3UI>